



Flight Experiments for Living With a Star Space Environment Testbed (LWS SET) –

Relationship to Technology

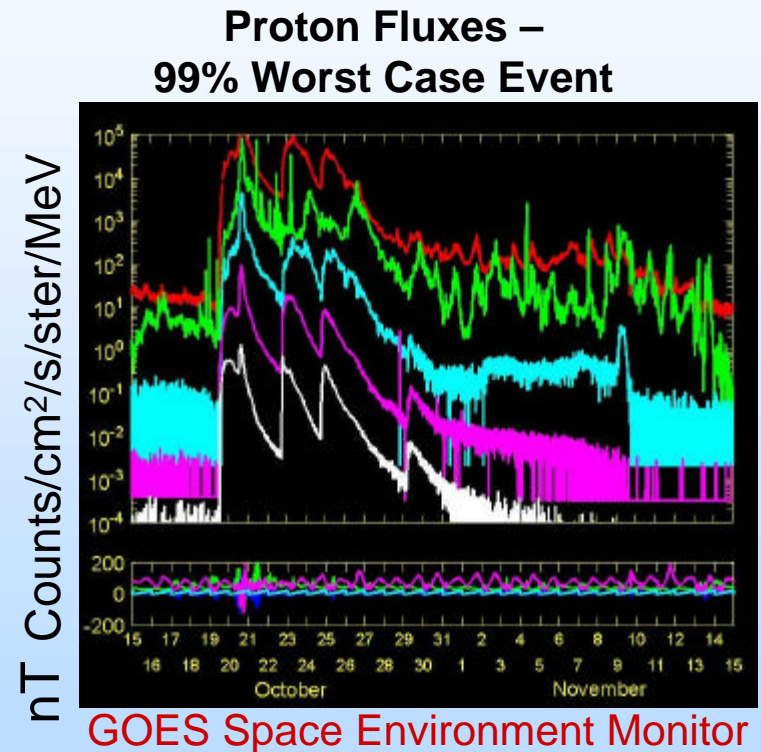
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Outline

- **Introduction**
 - LWS SET overview
 - SET flight experiment goals
 - SET Experiment Services
- **Flight Experiments**
 - Experiment Selection Process
 - SET Pathfinder (SETPath) Experiments
 - NASA Research Announcement (NRA)
- **Collateral programs**
- **Comments**

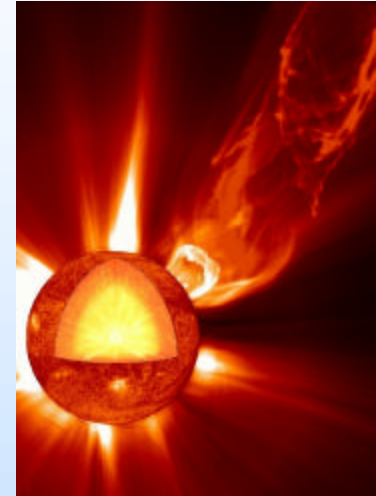




Living With a Star Program:

*a pure and applied science program with
an engineering application*

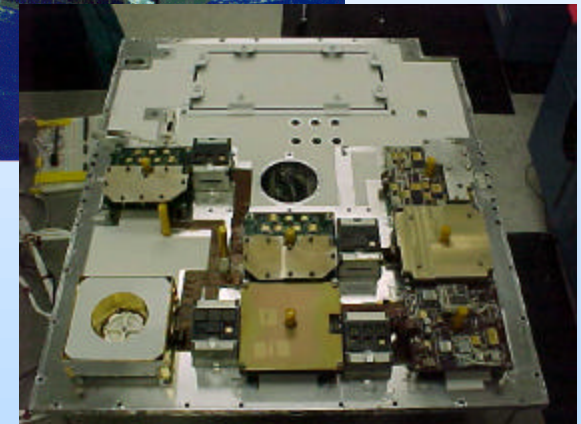
- **Program Goal** – *Perform investigations in space to understand solar variability & its effects leading to a reliable predictive capability of solar variability (i.e., space weather)*
- **LWS has three elements**
 - **Science Missions:** the what's and why's of the solar variant environment
 - Ex., Solar Dynamics Observer
 - **Theory and Modeling and Data Analysis:** the environment models and tools developed from solar-variant data
 - A sample product might be: Improved Trapped Particle Models
 - ***Space Environment Testbeds (SETs):*** *Improve the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design & operations*
 - **A sample of a predecessor: Microelectronics and Photonics Testbed (MPTB)**
- **Continuous program started in FY01**





SET Technologies

- SET provides opportunities for flight validation experiments on technologies
 - Microelectronics
 - Photonics
 - Materials
 - Sensors
 - Environment, imaging, etc.
- These investigations focus on
 - **Demonstration of environment tolerance**
 - Radiation hardening approaches
 - **Validation of technology ground test methods and performance prediction techniques**
 - Ex., correlate space dose rates to ELDRS sensitive device performance
- **Investigations must require exposure to solar-variant environment**

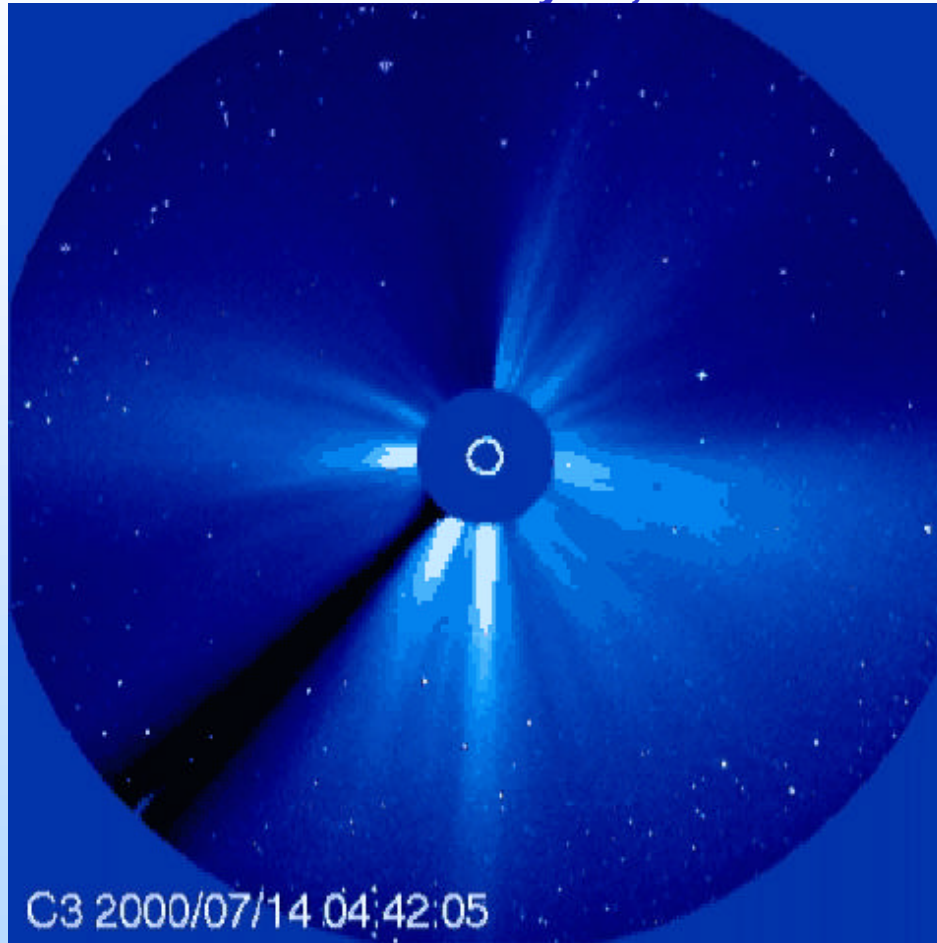


Space Technology Research Vehicle 1-d
with NASA experiments



Solar Variant Example: *SOHO/LASCO C3 Coronagraph*

July 14, 2000



Sample LWS SET Goals:
Understand enough about
the technology and the
environment to minimize
science data outages.
Validate cosmic ray
rejection methods...

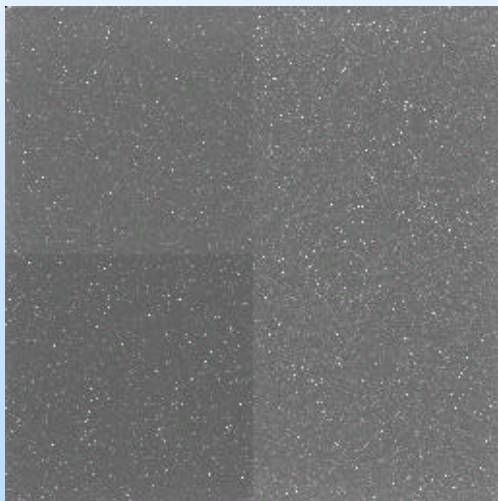
Solar storm induces transients in a Charge-Coupled Device (CCD)
view video at <http://radhome.gsfc.nasa.gov/radhome/papers/C3big480C.avi>



Sample Solar Variant Technology Effects: Radiation Effects on Spacecraft

- Long-term effects:
failure/degradation increases
with mission lifetime

- Total ionizing dose (TID)
- Displacement damage



Active Pixel Sensor courtesy of
Photobit Technologies via NASA SBIR
and DTRA Sensors Hardening Program

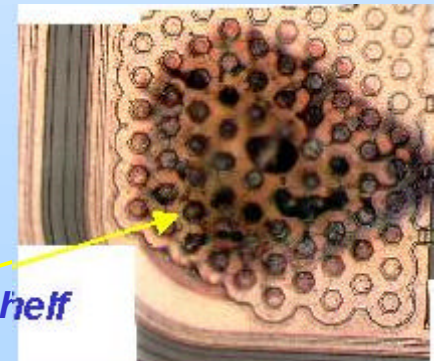
view video at

http://radhome.gsfc.nasa.gov/radhome/papers/D3_I030_2100_2199.avi

- Transient or single particle
effects (Single event effects
or SEE): random strikes by a
particle

- Soft or hard errors

- Four quadrants, each representing a different design
- Particle hits spread among multiple pixels
- Ion strikes are minimized by utilization of a non N-well, n+ recessed implant photodetector design



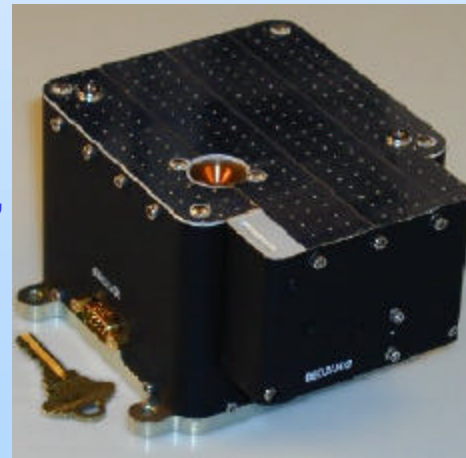
*Destructive SEE
in a commercial-off-the-shelf
(COTS) 120V device,
after Howard, 2002*



Other Technology Effects of Interest to LWS SET - Examples

- **Spacecraft charging**
 - May be the single largest cause of space environment induced anomalies
 - Can damage solar arrays, electronics, etc
- **Material degradation**
 - Brittleness, optical property degradation, thermal effectiveness,...

CEASE II instrument,
www.amptek.com





SET Services Provided to Experiments

SETPayload

Card or Box

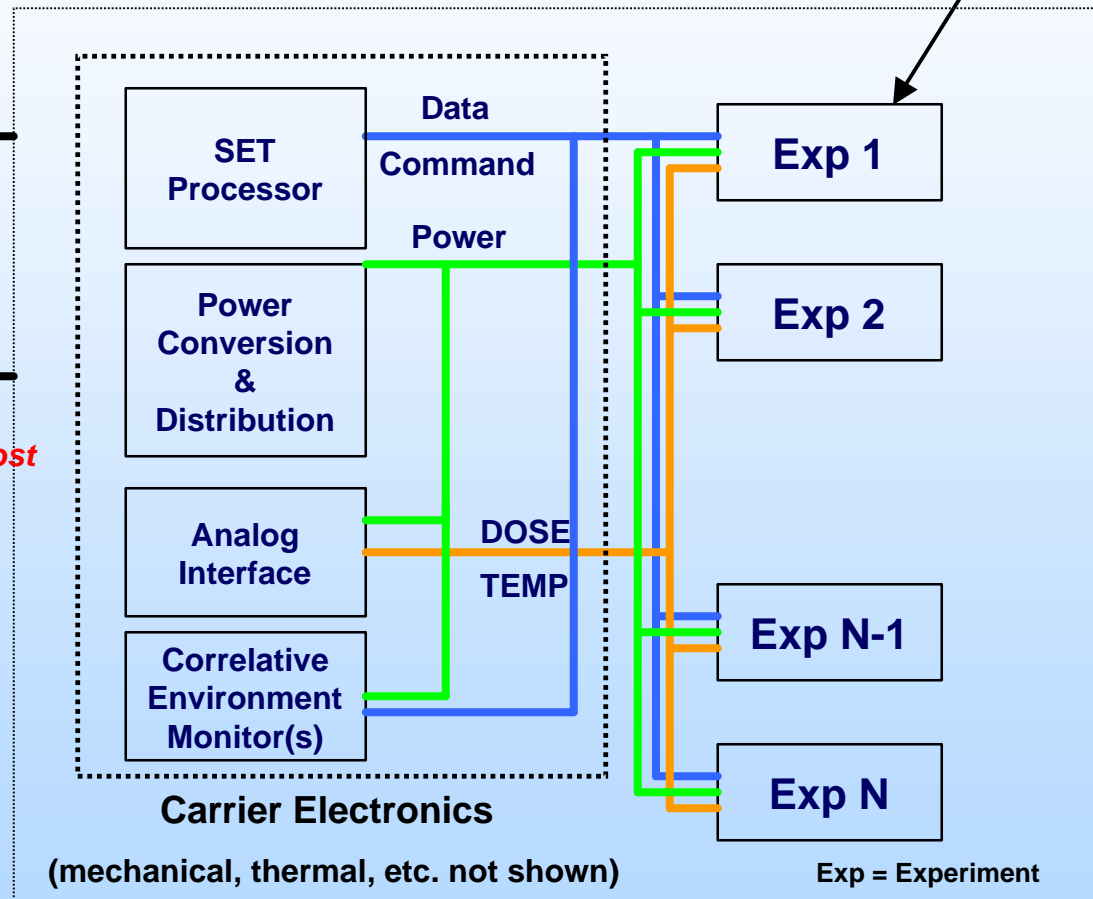
RS-422
or other

Host S/C

28V

- one data and command interface to host
- one power interface to host

Experiments may alternately
fly without carrier if
host S/C agreement is
included



+ NASA and DTRA are collaboratively investigating infrastructure requirements for imaging sensors



Flight Experiment Selection Process:

Two methods

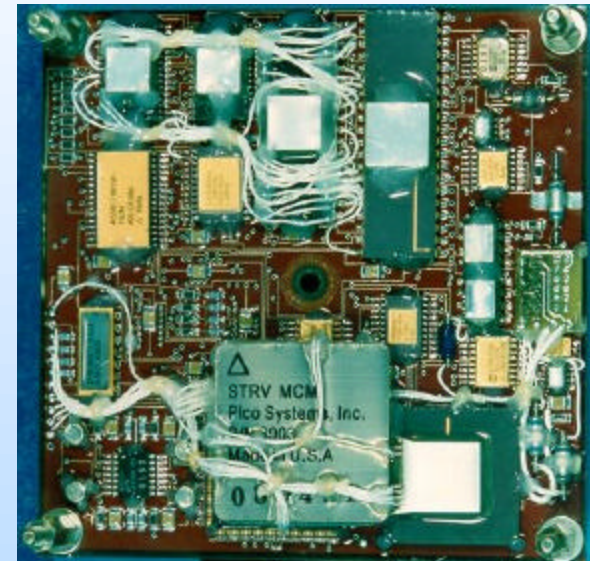
- **NRA: a competitive action for investigations**
 - Proposal process
 - Must demonstrate need to fly in solar-variant environment
 - Must have collateral ground test and/or model development program
 - No technology development efforts funded by this NRA
 - Data is non-proprietary (may be ITAR)
 - No funds exchanged with international entities
- **Partnering**
 - Partner may provide investigation(s) outside of the NRA process in exchange for support of the LWS SET Program
 - Funding
 - Launch opportunity
 - Infrastructure, etc...
 - Data can be proprietary or secure





SETPath Experiments Overview

- **SETPath experiments are based on flight investigations originally designed for Space Technology Research Vehicle – 1d (STRV-1d) mission**
 - No data returned due to spacecraft communications system failure
 - Originally selected by a peer team for STRV-1d inclusion
 - Some updates provided to original experiment to increase investigation utility
- **Five experiment cards**
 - COTS-1a: Linear Single Event Transients (LSETs)
 - COTS-1b: Enhanced Low Dose Rate Sensitivity (ELDRS)
 - COTS-2a: Digital Commercial-off-the-Shelf (COTS) Electronics
 - COTS-2b: Field Programmable Devices
 - COTS-3: Optocouplers



**STRV-1d COTS 2a
Flight Prototype**



COTS-1a:

Linear Single Event Transients (LSET)

Purpose

- Collect data in space to validate single event transient (SET) performance models & test protocols for linear bipolar devices

NASA Benefit

- Provide more consistent performance & lifetime; lower likelihood of LSET anomalies as observed in Cassini, MAP, & TDRSS

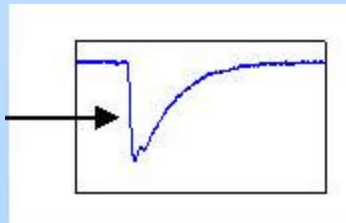
NASA Application

- Linear bipolar devices are common in comparators and operational amplifiers -- basic building blocks in all NASA spacecraft & instruments

History

- Designed for STRV 1-d; will be built by [Aerospace Corp](#)

A sample LSET,
after Poivey, 2002



Partners

- Aerospace Corp., NASA/GSFC, NAVSEA-Crane, Vanderbilt University, JPL, DoD, Industry, RLP

Leveraging

- The NASA Electronics Parts & Packaging (NEPP) and DTRA supports development of ground radiation tests, protocols, & prediction models
 - Ground test protocol will be issued in FY 20032 (Poivey/GSFC)
 - Supports Vanderbilt model development
- Devices provided by industry (NSC, et al?)

Development Path

- Modification of existing design (Koga & Crain/Aerospace Corp)

Delivery Date: Jan 2004

Risk of Schedule Slip

- Low; based on existing design



COTS-1b:

Linear Enhanced Low Dose Rate Sensitivity (ELDRS)

Purpose

- Collect data in space to validate ground test protocols for linear bipolar devices that exhibit ELDRS
 - ELDRS is failure at a lower cumulative total ionizing dose in space compared to traditional accelerated ground test dose rates

NASA Benefit

- Provide more consistent performance & lifetime

NASA Application

- Linear bipolar devices are common in comparators and operational amplifiers -- basic building blocks in all NASA spacecraft & instruments

History

- Early experiment concept successfully flown on MPTB by NAVSEA-Crane (COTS-1b experiment developer)

Partners

- NAVSEA-Crane, Vanderbilt University, NASA/GSFC, JPL, DoD, Industry, RLP

Leveraging

- The NASA Electronic Parts & Packaging Program (NEPP) delivers a ground test & technology guideline in FY 2003 (Johnston/JPL)
 - Devices provided by industry (NSC, et al)
- Mil 1019.6

Development Path

- Modification of existing design by NAVSEA-Crane (Turflinger, et al)

Delivery Date: Jan 2004

Risk of Schedule Slip

- Low; based on flight-heritage design



COTS-2a: Digital COTS

Purpose

- Collect data in space to validate single event effect (SEE) & total ionizing dose (TID) performance models for:
 - Commercial fuzzy logic processors;
 - Static random access memories (SRAM); &
 - Field programmable gate array (FPGA) logic devices

NASA Benefit

- Reduce design margins & provide more consistent performance in space

NASA Application

- *Fuzzy logic: Robotics, docking, & constellation management applications*
- *SRAMS: Solid state recorders*
- *FPGAs: Replace custom solutions*

Partners

- NASA/GSFC, CNES, ONERA, TIMA

Development Path

- Modification to existing STRV 1-d flight card for LWS SET carrier interface ([NASA/GSFC](#))

Delivery Date: November 2003

Risk of Schedule Slip

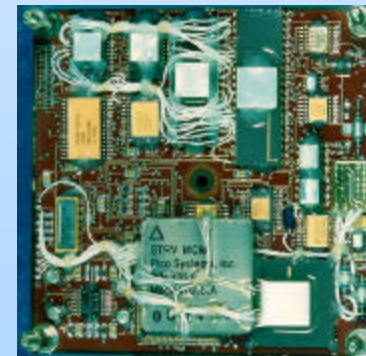
- Low; existing hardware

Ground data availability

- Heavy ion & proton data in hand from Orsay, France

History:

- Built for STRV 1-d but not flown





COTS-2b: FPGA Technology Concept Validation

Purpose

- Collect data in space to validate single event effect (SEE) and total ionizing dose (TID) performance models & test protocols for COTS and environment-hardened FPGAs

NASA Benefit

- Provide more consistent performance in spacecraft electronics systems.

NASA Application

- Replace custom solutions in electronics system design at a fraction of the cost in virtually all NASA spacecraft; save power, weight, volume, & schedule

History

- Designed for STRV 1-d by [NASA/GSFC](#); *devices will be updated to state of the art*

Partners

- NASA/GSFC, DoD, Industry, (is TIMA interested?)

Leveraging

- The NASA Electronics Parts & Packaging Program supports development of ground test protocols, guidelines, & technology development
- Devices provided by DoD & industry

Development Path

- Existing design (Katz - NASA/GSFC) with mission-specific modifications

Delivery Date

- Jan 2004

Risk of Schedule Slip

- Low – existing design with experienced flight designer



COTS-3: Optocouplers

Purpose

- Collect data in space to validate single event effect (SEE), total ionizing dose (TID), and device displacement damage (DDD) performance models & test protocols for optocouplers
 - Portions of the models may also be applicable to high-speed fiber optic links

NASA Benefit

- Reduce design margins & increase reliability
 - Anomalies on HST, TERRA, & TOPEX/Poseidon)

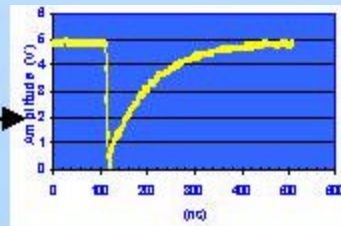
NASA Application

- Used to isolate electrical signals between spacecraft sub-systems & instruments; ex., power converters

History

- Designed for STRV- 1d by **NASA/GSFC**; new optocouplers will be utilized for SETPath

A sample SET, after Reed, 1998



Partners

- NASA GSFC, JPL, DoD, Industry

Leveraging

- The NASA Electronic Parts & Packaging Program (NEPP) and DTRA deliver a ground test & technology guideline in FY 2003 (Reed/GSFC)
- Devices provided by industry

Development Path

- Existing design; mission-specific interface modifications & newer devices (Buchner – GSFC)

Delivery Date: Jan 2004

Risk of Schedule Slip: Low; based on an existing design

Ground data availability

- Heavy ion & proton data in hand; all new ground data to be funded by NEPP



Collateral Programs

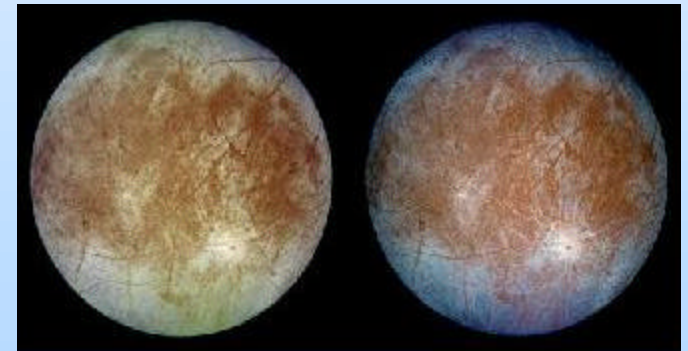
- **Ground-test programs are developing protocols or that require validation. Examples include:**
 - **Electronics**
 - NASA Electronic Parts and Packaging (NEPP) Program
 - Defense Threat Reduction Agency's (DTRA's) Radiation Hardened Microelectronics (RHM) Program
 - Air Force Space and Missile Command
 - ESA
 - CNES
 - **Materials**
 - Air Force Wright Patterson
- **Environment-tolerant approaches require validation**
 - Air Force Research Laboratories
 - DTRA
 - Industry





Final Comments

- **Ground test methods require validation with in-flight data**
 - Must have correlative environment monitors (CEMs) or we can't adequately reduce design margins
- **No one likes to be the first to fly a new solution**
 - LWS SET can provide that opportunity for new technologies that require solar-variant environment validation
- **NRA results due out in near-term**
 - Future NRA planning has begun
- **Collaboration with others is critical**
- **Contact for more info**
 - kenneth.a.label@nasa.gov
 - <http://lws-set.gsfc.nasa.gov>
 - <http://nepp.nasa.gov>



Europa: future challenges for radiation, temperature, and lifetime